

June 5, 1951

H. IAMS

2,556,087

DIRECTIVE ANTENNA SYSTEM

Filed Feb. 27, 1948

FIG-1

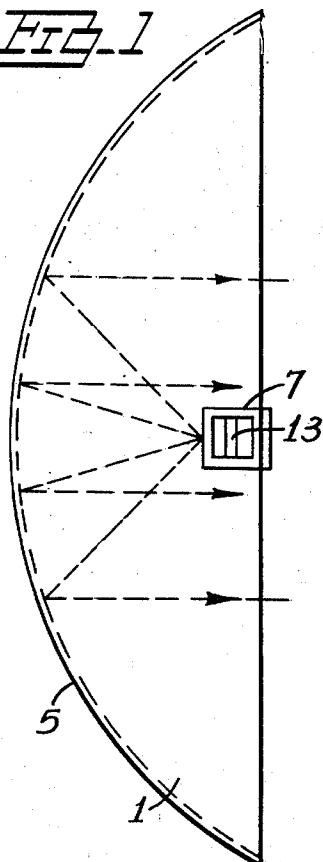


FIG-4

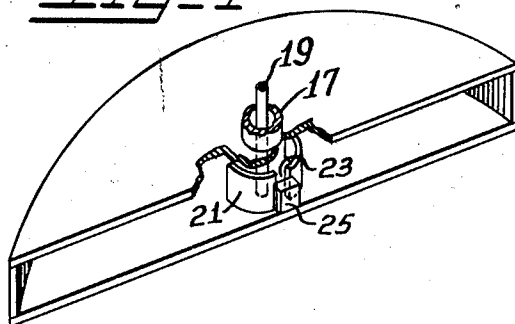


FIG-5

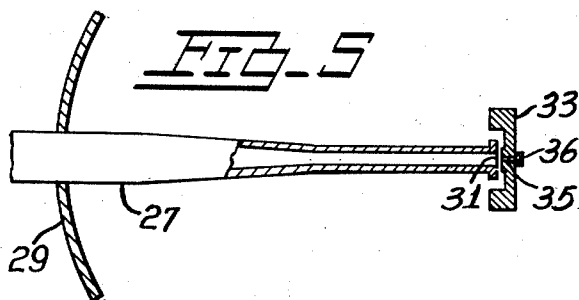


FIG-3

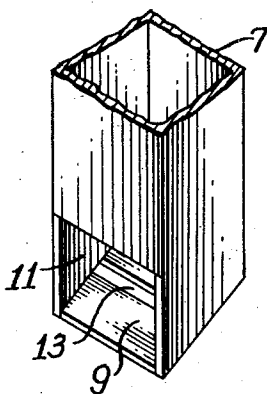
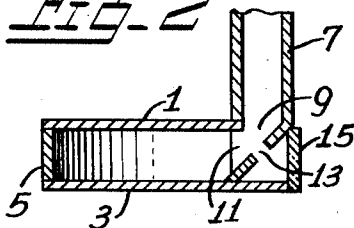


FIG-2



INVENTOR
Harley Iams
BY *J. L. White*
ATTORNEY

UNITED STATES PATENT OFFICE

2,556,087

DIRECTIVE ANTENNA SYSTEM

Harley Iams, Venice, Calif., assignor to Radio Corporation of America, a corporation of Delaware

Application February 27, 1948, Serial No. 11,401

10 Claims. (Cl. 250—33.65)

1

2

This invention relates to improvements in directive antennas, more particularly antennas of the type including a beam-forming reflector such as a paraboloidal sheet. One of the problems which arises in the use of such antennas is that of feeding or "illuminating" the reflector without undue distortion of the directive pattern by the masking effect or "shadow" of the feed structure. The difficulty may be avoided by using an offset reflector, with the focal point and the feed structure outside the main beam. However, this arrangement requires an antenna of greater overall dimensions than a symmetrical arrangement, for the same beam width or gain.

When a reflector which is symmetrical about the axis of the main beam is used, the feed structure must be located in the path of the reflected energy, and its presence causes a region of low intensity or "shadow" in the wave front. The effect is to subtract from the undisturbed directive pattern a broad "shadow pattern" which decreases the size of the main pattern lobe and increases the undesired secondary lobes.

It is the principal object of the present invention to provide methods and means for compensating or neutralizing the above described shadow effect.

More specifically, it is an object of this invention to provide improved feed structures for antennas of the type including beam-forming reflectors.

The foregoing objects are achieved in accordance with the instant invention by providing the feed structure with means for radiating a portion of the available power in the direction opposite the reflector. This power is made to have an amplitude and phase approximately equal to that masked by the feed device.

The invention will be described with reference to the accompanying drawing, wherein:

Figure 1 is a plan view of a directive antenna of the so-called "pillbox" type, embodying the invention.

Figure 2 is a sectional view in elevation of the structure of Figure 1.

Figure 3 is a perspective view of the feed structure of the device of Figure 1.

Figure 4 is a perspective view of a modification of the antenna of Figure 1, and

Figure 5 is a view in elevation, partly in section, of a rear feed horn which embodies the present invention.

Referring to Figures 1 and 2, the "pillbox" includes two flat parallel metal sheets 1 and 3 partially enclosing a relatively narrow strip 5

which is curved about a vertical axis to form a short cylindrical paraboloid. A hollow metal-walled wave guide 7 extends vertically down through the center of the forward edge of the upper sheet 1, terminating in a right-angle bend 9 at the center of the rectangular aperture formed by the sheets 1 and 3 and the strip 5. The mouth or opening 11 of the wave guide 7 is substantially at the focus of the paraboloid formed by the strip 5.

A narrow horizontal slit 13 is provided in the wall of the guide 7 at the bend 9, on the side away from the opening 11. The optimum width of the slit 13 depends on the relation between the size of the pillbox aperture and the size of the wave guide, but generally will be between one-fourth and one-tenth the height of the open end of the wave guide. A body 15 of dielectric material such as polystyrene covers the slit 13. The thickness of the body 15 depends upon the dimensions of the pillbox and the wave guide 7 and is most conveniently determined experimentally as will be described.

The adjustment and operation of the above-described antenna is as follows:

A radio receiver, not shown, which may comprise merely a detector and an indicator, is coupled to the upper end of the wave guide 7. A transmitter is set into operation at some relatively remote point, and the pillbox aligned so as to receive the transmitted signal on the largest side lobe or secondary lobe of the pillbox directive pattern. The width of the slit is made some arbitrary value, and a tapered wedge of dielectric material is moved across the position to be occupied by the body 15, to determine the thickness which results in a minimum response.

The above procedure is repeated, using different slit widths, to obtain the combination of dielectric thickness and slit width for least response in the largest secondary pattern lobe. To a first approximation, this adjustment will minimize all the side lobes simultaneously, while increasing the sharpness of the main beam.

In the operation of the antenna for transmission, energy is supplied to the upper end of the wave guide 7, and travels to the bend 9, where the most of it emerges from the opening 11 toward the strip 5. The strip 5 reflects and concentrates the energy in substantially parallel rays, as indicated by the dash lines in Figure 1. The wave guide 7 obscures the central part of the resulting wave front, however, tending to widen the beam. This effect is overcome by energy radiated from the slit 13. The dielectric body

3

15 delays the energy radiated from the slit 13 by the amount necessary to bring it into phase with that which is masked off by the wave guide. The overall result is approximately the same as if the wave guide 7 were transparent to the energy reflected from the strip 5.

It will be apparent that the operation for reception is substantially the reciprocal of that for transmission: the received energy which is masked off by the wave guide and thus does not reach the reflector strip 5 is compensated by energy which enters the slit 13 directly, without reflection. Therefore the optimum adjustments of slit width and dielectric thickness for reception are also optimum for transmission.

The antenna of Figure 1 is particularly suited for horizontally polarized fields, wherein the electric vector is parallel to the sheets 1 and 3. The spacing between the sheets 1 and 3 must be greater than one-half wavelength, and the propagation through the guide 7 is in the so-called TE_{01} mode.

Figure 4 shows an antenna generally similar to that of Figure 1 but arranged for operation with vertically polarized fields. The "pillbox" is similar to that of Figure 1, and its parts are designated by corresponding reference characters. The feed device in this example comprises a coaxial line, with its outer conductor 17 terminating on the upper sheet 1 and its inner conductor 19 extending across the opening of the pillbox at its focus. A cylindrical reflector 21 partially surrounds the exposed lower end of the conductor 19 to direct radiation therefrom toward the reflecting strip 5.

As in the system of Figure 1, the feed structure obscures the central part of the main beam. To neutralize the resulting "shadow," a vertical slit 23 is provided in the cylindrical reflector 21. This slit is covered by a body 25 of dielectric material to introduce the required phase delay. The electric field vector is perpendicular to the sheets 1 and 3 in Figure 4. Otherwise, the operation and adjustment are like that of the device of Figure 1.

The invention has been described thus far with reference to "pillbox" type reflectors comprising cylindrical paraboloids bounded by flat parallel sheets. It will be apparent, however, that the invention is not limited thereto, and may be practiced with other types of reflector configurations and other types of feed devices.

One prior art feed device which presents a partial solution to the problem of feed masking is the so-called "rear feed," wherein a rearwardly directed radiator is supported on a wave guide extending through the back of the reflector and along the principal directive axis. A structure of this type, improved in accordance with the present invention, is shown in Figure 5. A wave guide 27 extends through the back of a reflector 29, which may be a cylindrical paraboloid, a paraboloid of revolution, or other beam-forming shape, and terminates in an aperture 31 facing away from the reflector. A metal cap 33 is supported on the end of the wave guide 27, near the aperture 31, and is shaped so as to return or reflect energy radiated therefrom back toward the main reflector 29. "Shadow" effect is minimized because the cap 33 and its supporting wave guide 27 may be made small so as to intercept but little of the energy reflected from the reflector 29.

The performance of the rear feed structure of Figure 5 is improved, in accordance with the pres-

4

ent invention, by providing a small opening 35 in the cap 33, of such dimensions as to radiate about the same power as is intercepted by the feed. As in the other embodiments described above, the phase of the energy radiated through the opening 35 may be delayed by a cover 36 or filling of dielectric material. Alternatively, the opening 35 may be designed to act as a wave guide operating near its cutoff frequency, and introduce an advance in the phase of the energy travelling through it. The length of the passage 35 through the cap 33 must then be made such as to provide the required change in phase.

Summarizing briefly, the present invention contemplates the reduction or elimination of "shadow" effects caused by the presence of the feed structure within the beam formed by a reflector, by radiation of power in the direction away from the reflector, in the same phase and amplitude as the power masked by the feed.

I claim as my invention:

1. In a directive antenna system including a reflector, a radiator arranged to illuminate said reflector with energy radiated therefrom and partially intercepting the energy reflected from said reflector, said radiator comprising a conductive sheet having a slot therein, said slot being positioned to radiate in substantially the same direction as the principal direction of reflected radiation from said reflector, and means delaying the phase of radiation from said slot to make such last-mentioned radiation conform in phase with that intercepted by said radiator.

2. In a directive antenna system including a reflector, a radiator arranged to illuminate said reflector with energy radiated therefrom and partially intercepting the energy reflected from said radiator, said radiator comprising a conductive sheet having a slot therein, said slot being positioned to radiate in substantially the same direction as the principal direction of radiation reflected from said reflector, and means for making the radiation from said slot conform in phase with that intercepted by said radiator.

3. The invention set forth in claim 2, wherein the width of said slot is such that the amplitude of the energy radiated therefrom is substantially the same as that of said energy intercepted by said radiator.

4. A directive antenna system including a reflector comprising a parabolic cylinder bounded by flat parallel plates, a wave guide extending substantially at right angles to said plates and terminating in an opening at the focus of said cylinder and facing toward said reflector, said wave guide including a second opening facing away from said reflector, and a body of solid dielectric material through which energy from said second opening passes for making the phase of the radiation from said second opening conform in phase with that intercepted by said wave guide.

5. A directive antenna including two parallel flat sheets of conductive material, a strip of conductive material in the form of a parabolic cylinder joining said sheets with its axial plane perpendicular to said sheets, a wave guide extending substantially along the focal line of said cylinder and terminating in a right-angle bend toward said cylinder and having walls, that wall portion of said wave guide most remote from said cylinder at said bend including a slot whose width is between one-fourth and one-tenth the distance between said flat sheets, and a sheet of dielectric material covering said slot.

5

6. A feed structure for a paraboloidal reflector, comprising a hollow wave guide terminating in an opening which faces away from the reflector, a conductive body adjacent said opening and formed to direct radiation therefrom toward said reflector, said body including an opening which faces away from said reflector, and means altering the phase of energy radiated through said last-mentioned opening.

7. A feed structure for a paraboloidal reflector comprising a radiator, means directing the major portion of radiation therefrom in one direction for reflection by said reflector, said means causing a shadowed space in the radiation pattern of said reflector with said means, and means directing a relatively small portion of the radiation from said radiator in the opposite direction into the shadowed space, said last-mentioned means including means introducing a predetermined delay in the phase of said radiation therefrom.

8. A feed structure for directive antenna systems having a reflector, comprising a hollow rectangular wave guide having an opening facing said reflector, a flat sheet of conductive material at one end of said wave guide and at an angle of 45 degrees to the direction of propagation of energy therein and in a position at the end of said wave guide to direct energy therefrom to said reflector, the radiation pattern of said reflector and feed structure having a shadowed space, said sheet including a slot lying perpendicular to said direction of propagation and having a width between one-fourth and one-tenth the width of said wave guide radiation through said slot from the side of said sheet facing said reflector to the other side illuminating said

6

shadowed space to compensate for the shadow, and a body of solid dielectric material positioned to be traversed by energy passing through said slot and not by energy not passing through said slot.

9. A directive antenna system comprising, a reflector, a feed structure arranged to illuminate the reflector as a transmitting antenna or receive energy reflected therefrom as a receiving antenna, said feed structure including a transmission line having a portion forming a shadowed space in the radiation pattern of the reflector, said transmission line having a radiator directing energy away from said reflector into said shadowed space as a transmitting antenna or intercepting energy directed toward said reflector as a receiving antenna from said shadowed space, thereby to compensate for the shadow of the radiation pattern without said radiator.

10. The antenna system claimed in claim 9, said transmission line radiator comprising a slot in a conductor of said transmission line.

HARLEY IAMS.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,129,712	Southworth	Sept. 13, 1938
2,273,447	Ohl	Feb. 17, 1942
2,407,318	Mieher et al.	Sept. 10, 1946
2,422,184	Cutler	June 17, 1947
2,429,640	Mieher et al.	Oct. 28, 1947
2,436,408	Tawney	Feb. 24, 1948
2,447,549	Willoughby	Aug. 24, 1948